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Guidance Manual on Hazardous Waste Land Treatment Closure/Post-Closure, 40 CFR Part 265

Utah State Univ., Logan

Prepared for

Environmental Protection Agency, Washington, DC

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

APR 14 1987

MEMORANDUM

SUBJECT: Part 265 Land Treatment Closure/Post-Closure Guidance

FROM: Marcia Williams, Director Marcia Williams
Office of Solid Waste

TO: Hazardous Waste Management Division Directors
Regions I-X

To assist permit writers and owners/operators of those land treatment units that may be closing, OSW is issuing the Guidance Manual on Hazardous Waste Land Treatment Closure/Post-Closure: 40 CFR Part 265. A copy of the manual is attached. This guidance manual addresses closure and post-closure of hazardous waste land treatment (HWLT) units under 40 CFR Part 265 Subpart G and Section 265.280 of Subpart M. The guidance is not intended to be a detailed technical document, but rather a document that provides general guidance to owners and operators of HWLT units and permit writers on implementing Part 265 closure regulations. I want to emphasize that the methods described in the manual are for guidance only and are neither requirements nor regulations. An applicant may use alternative methods, provided that these methods comply with applicable regulatory requirements.

This manual specifically addresses five areas:

(1) general information on HWLT and methods of closure, (2) objectives of closure and post-closure, (3) factors affecting closure and post-closure, (4) methods for addressing closure and post-closure based on migration potential, and (5) management during closure and post-closure.

Finally, I want to stress that completion of a successful land treatment closure would provide valuable information that should be shared among Regions. Therefore, when such information becomes available, I would appreciate your efforts to inform the appropriate Headquarters Permit Assistance Team members.

If your staff has questions regarding this guidance, please contact Jon Perry, on 8-382-4654 in the Land Disposal Branch for further information.

Attachment

cc with Attachment:
RCRA Branch Chiefs, Regions I-X
Permit Section Chiefs, Region I-X
Joe Carra
Susan Bromm
Sylvia Lowrance

GUIDANCE MANUAL ON

HAZARDOUS WASTE LAND TREATMENT CLOSURE/POST-CLOSURE

40 CFR PART 265

INTERIM FINAL

Prepared for

Office of Solid Waste
U.S. Environmental Protection Agency
Washington, D.C. 20460

by

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April, 1987

TABLE OF CONTENTS

	Page
1.0 Considerations for Closure and Post-closure of Hazardous Waste Waste Land Treatment Units Under 40 CFR Part 265	1
1.1 Purpose of manual	1
1.2 Overview of manual	1
1.3 Approach to closure and post-closure	1
1.4 General information on hazardous waste land treatment	7
2.0 Factors in Addressing Closure and Post-closure	9
2.1 Introduction	9
2.2 History of waste application	9
2.3 Mobility and migration potential	9
2.4 Environmental site conditions	11
2.5 Waste residue characterization in the unsaturated zone	11
3.0 Methods for Addressing Closure Based on Mobility and Migration Potential	18
3.1 Suggested closure methods	18
3.2 Factors to be considered in the selection of a closure method	18
3.3 Removal of contaminated soil as a closure method	21
3.4 Establishment of a final cover as a closure method	22
3.5 Continued groundwater monitoring	28
3.6 In-place treatment as a closure method	28
4.0 Management During Closure	
4.1 Introduction	31
4.2 Unsaturated zone monitoring	31
4.3 Run-on and run-off control	32
4.4 Control of dispersal of particulates	32
5.0 Management during Post-closure	33
5.1 Post-closure requirements	33
5.2 Duration of post-closure care	33
References	35
Appendix A	38

Chapter 1

CONSIDERATIONS FOR CLOSURE AND POST-CLOSURE OF HAZARDOUS WASTE LAND TREATMENT UNITS UNDER 40 CFR PART 265

1.1 PURPOSE OF MANUAL

This guidance manual addresses closure and post-closure of hazardous waste land treatment (HWLT) units under 40 CFR Part 265 Subpart G and Section 265.280 of Subpart M. The guidance provided is not intended to be a detailed technical document, but rather a document that provides general guidance to owners and operators of HWLT units and permit writers on implementing Section 265 closure regulations. The guidance contains a discussion of options that may be pursued in implementing closure and post-closure requirements.

1.2 OVERVIEW OF MANUAL

This manual specifically addresses five areas including: (1) general information on HWLT and methods of closure, (2) objectives of closure/post-closure, (3) factors affecting closure and post-closure, (4) methods for addressing closure and post-closure based on migration potential, and (5) management during closure and post-closure. This guidance also summarizes relevant information from additional U.S. Environmental Protection Agency (EPA or Agency) publications and refers the user to EPA publications for background and for additional information supporting approaches for site characterization, chemical analyses, establishment of cover, etc.

1.3 APPROACH TO CLOSURE AND POST-CLOSURE

The owner or operator of a hazardous waste management facility must submit a closure plan to the EPA Regional Administrator at least 180 days prior to the date on which closure is expected to begin at the first unit at the facility. Owners or operators with approved closure plans must notify the Regional Administrator in writing at least 60 days prior to the date on which closure is expected to begin at a HWLT unit at the facility (Section 265.112 (d) (1)).

Within 30 days after receiving the known final volume of hazardous waste, the owner or operator of the HWLT unit must commence closure in accordance with the approved closure plan (Section 265.112 (d) (2)). The closure plan should identify steps necessary to completely or partially close the facility at anytime during the facility's intended operating life, and to completely close the facility at the end of its operating life. At a minimum, the closure plan must include (Section 265.112(b)(1)-(7)):

(1) a description of how each waste management unit at the facility will be closed in accordance with the performance standards given in Section 265.111;

(2) a description of how final closure of the facility will be conducted in accordance with Section 265.111, including a description of the maximum extent of the operation that will be unclosed during the active life of the facility;

(3) an estimate of the maximum inventory of hazardous wastes in storage or treatment at the facility during its operating life;

(4) a description of methods to be used during partial and final closure, including, but not limited to methods for removing, transporting, treating, storing, or disposing of all hazardous waste, and identification of and the type(s) of off-site hazardous waste management unit(s) to be used, if applicable;

(5) a description of methods for decontamination of system components, equipment, and structures, including criteria for determining the extent of decontamination necessary to satisfy the closure performance standard (Section 265.111);

(6) a description of other activities necessary for closure, including run-on and run-off control systems, groundwater monitoring and other monitoring systems;

(7) a schedule of closure for each hazardous waste management unit and for final closure of the facility, including specific periodic reporting dates to monitor progress; and

(8) an estimate of the expected year of final closure for facilities that use trust funds to demonstrate financial assurance (Sections 265.143 or 265.145) and whose remaining operating life is less than 20 years.

The owner or operator may amend the closure plan at any time prior to the notification of partial or final closure of the facility in accordance with Section 265.112 (c). The closure plan must be amended if there are changes in operating plans or facility design that will affect the closure plan, if there is a change in the expected year of closure, or if during the performance of partial or final closure activities, unexpected events require a modification of the closure plan (Section 265.112 (c) (1) (i), (ii), and (iii)).

Financial responsibility requirements to ensure that owners or operators of hazardous waste management facilities have adequate funds to implement closure and post-closure plans are given in Subpart H of Part 265. In general, the regulations require that the owner or operator have written estimates of the cost of closing the facility and the annual cost of a post-closure monitoring and maintenance program. The owner or operator must also adopt one of the financial instruments provided by the regulations to assure financial responsibility.

Additional specific requirements that must be addressed in the closure plan for a HWLT unit are given in Section 265.280. The goal of closure of a unit is to control, minimize or eliminate any potential for damage to human health and the environment (Section 265.111). Closure of the HWLT unit is therefore concerned with the extent of degradation, transformation, and immobilization of constituents within a defined treatment zone, and the control of pathways of migration of hazardous waste and hazardous waste constituents into the environment, including groundwater, surface water, atmosphere, and food-chain crops grown on site (Section 265.280(a) (1)-(4)). The effectiveness of previous treatment of hazardous waste and hazardous waste constituents in the treatment zone soil (Section 265.280(b)(1),(2),(6) and (7)) is determined from a site reconnaissance study and from historical records of waste application and site sampling. Information requirements for site characterization are specified in Section 265.280(b)(3),(4) and (5).

The guidance provided in this manual for approaches and criteria for utilizing appropriate methods for closure and post-closure, including but not limited to those identified in Section 265.280(c), i.e., (1) soil removal, (2) cover or cap placement, and/or (3) groundwater monitoring, is based on site-specific information. This information includes waste type and constituents, soil type(s), climate, and extent of degradation, transformation, and immobilization of hazardous waste and hazardous waste constituents within a defined treatment zone. The information is used to predict potential pathways of migration of hazardous waste and hazardous waste constituents into the environment. Closure by soil removal may limit or eliminate the potential for future migration by eliminating or reducing contamination at the source, while closure by cover placement may limit or eliminate direct contact and inhalation exposure and/or limit or eliminate leachate production by minimizing infiltration.

Continued in-place treatment of applied hazardous wastes is also a method recommended for use during the closure period at a HWLT unit. In-place treatment may consist of a continuation of the operating and management practices utilized during the active life of the facility, or use of additional amendments or techniques for enhancing degradation, transformation, and/or immobilization.

Another approach presented in this guidance combines the use of two or more of the recommended closure methods to achieve control of migration of hazardous wastes and hazardous waste constituents from the HWLT unit. For example, partial removal of more highly contaminated soil may be followed by covering the unit, or by continued in-place treatment followed by establishment or placement of a cover.

The closure plan submitted by the owner or operator must include a method for evaluation of the potential migration of residual waste constituents to environmental media, including groundwater, surface water, and atmosphere (Sections 265.111 and 265.280 (b) (2)). An evaluation of potential migration pathways of concern requires site-specific information concerning waste residues and site/soil characteristics and may involve the use of laboratory studies and/or mathematical models for predicting the rate and amount of migration of constituents into the environment. Levels of constituents in

leachates or emissions may be determined by the use of soil leaching or volatilization tests or estimated based on known characteristics of the waste constituents and soil characteristics (e.g., solubility and partitioning coefficients). The mathematical model presented in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a) was developed by Short (1985) specifically for evaluation of degradation and immobilization of individual organic waste constituents in a land treatment unit, and for assessment of the potential migration of individual constituents to groundwater and to atmosphere. The model can be used on IBM-compatible personal computers (PCs). The model can be used to predict the fate and relative concentration of hazardous constituents at point(s) of exposure, thus indicating potential migration pathways of concern that should be controlled. A detailed description of the model program, including capabilities, assumptions, and limitations, rationales for selected input criteria, methods, and information for using the model is given in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a). A method for evaluation of the potential for migration of metal constituents to groundwater for hazardous waste/soil residues using sequential desorption, adsorption, and column leaching tests is presented in Protection of Groundwater by Immobilization of Heavy Metals in Industrial Waste Impacted Soil Systems (Sims and McLean 1986). The geochemical model MINTEQ may also be used to determine estimates of metals species distributions that can be used to predict migration potential of metals (Felmy et al. 1984).

The time required for closure will be a function of the method chosen for closure. If the wastes are left in place for continued treatment, the length of time required for closure will be related to the time required for the degradation of hazardous waste and hazardous waste constituents to achievable levels protective of human health and the environment. While Section 265.113(b) requires that closure be completed within 180 days after receiving the final known volume of hazardous wastes at the HWLT unit, caution should be taken not to close a unit before satisfactory levels are achieved. The Regional Administrator may approve an extension to the closure period if the owner or operator demonstrates that closure activities will take longer than 180 days to complete (Section 265.113(b)(1)(i)). Closures by soil removal or by clay or synthetic capping are expected to require the least time, usually within the 180 day period given in Section 265.113(b), while closure by vegetative cover or a combination of approaches requires time periods dependent upon biological processes and can also be anticipated to be seasonally dependent. Therefore, closure activities at a HWLT unit may often be expected to continue longer than 180 days. Also, if a vegetative cover is used as part of a closure method utilizing continued treatment, sufficient time must be allowed for degradation and detoxification of soil/waste residues so that a vegetative cover can be established and maintained. A demonstration of the ability of the site to support vegetation is also recommended prior to the completion of closure.

Any unit that closes after January 26, 1983 is subject to obtaining a post-closure permit under Part 264 (Section 270.1 (c)). While the scope of Section 265.280 requirements is currently limited to hazardous waste and hazardous waste constituents (i.e., those listed in Appendix VII of Part 261), the post-closure permit must address hazardous constituents (i.e., those

listed in Appendix VIII of Part 261) (Section 264.280). Since evaluation of only hazardous waste and hazardous waste constituents under Section 265.280 may allow significant and potentially harmful levels of hazardous constituents to remain in HWLT units, it is recommended that owners/operators consider the performance of analysis and control of these constituents from the viewpoint of protection of public health and the environment, as required by Section 264.280. If approved by the permit writer, the hazardous constituents for wastes handled at a facility that are from an identified process (e.g.,) petroleum refinery processes) for which analysis is required may include only those hazardous constituents that are "reasonably expected to be in , or derived from, the wastes to be land treated" (Section 270.20 (b) (4). A list of Appendix VIII constituents commonly found in petroleum refinery wastes is included in Appendix A. For facilities other than petroleum refineries, guidance for determining hazardous constituents for which a facility should test could follow the guidelines given to facilities for preparation of petitions to delist hazardous waste (U.S. EPA 1985b). The permit writer and applicant should agree in writing on the specific subset of Appendix VIII constituents for which analysis will be required.

The closure performance standard given in Section 265.111 states that post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off, or hazardous waste decomposition products must be controlled, minimized or eliminated. The permit writer should use health-based acceptable concentrations, as described below, or remove constituents to background levels, or to levels achievable by the use of selected closure technology at the specific HWLT unit when Agency approved health-based levels are not available. These criteria should be used to assess risk due to direct contact with the unit soils (i.e., soil ingestion), exposure to ground water at the unit boundary, and surface water quality impacted by ground water discharge or surface runoff.

Concentration levels for Appendix VIII constituents for each potential route of exposure are based upon the most appropriate Agency-established health-based levels. The following levels should be used for setting closure target levels in each medium:

(1) for all routes of exposure involving a drinking water scenario, use Maximum Contaminant Levels (MCLs) established as drinking water standards under the Safe Drinking Water Act (SDWA). The Agency is in the process of proposing and finalizing additional MCLs and will continue to do so over the next several years;

(2) where no MCLs currently exist, however, the closure target levels involving a drinking water scenario should be based on Reference Doses (RfDs) for threshold contaminants, and Risk Specific Doses (RSDs) for non-threshold contaminants, assuming a risk level of 1/1,000,000 for Class A and B carcinogens and 1/100,000 for Class C carcinogens;

(3) for routes of exposure involving direct contact with the soil surface and direct soil ingestion, closure target levels should be based on RfDs and RSDs, as described above;

(4) for routes of exposure involving inhalation of chemical contaminants or particulate matter, the closure target level should be based on National Ambient Air Quality Standards (NAAQS) where they exist; where no NAAQS exist,

target levels based on RfDs and RSDs should be used, assuming an inhalation route of exposure;

(5) closure target levels for any medium (soil, air, or water) could be based on adverse effects on environmental systems or species; where such environmental effects are potentially significant, the closure target levels should be based on Federally-approved State Water Quality Criteria (for protection of aquatic species); the assumption is made that a contaminant in air, soil, or groundwater in addition to surface water could affect aquatic organisms;

(6) under certain circumstances, the closure target levels based on Agency-established human health standards (i.e., MCLs, RfDs, RSDs, etc.) may be lowered. Such circumstances include:

(a) where a mixture of contaminants is present in any one medium resulting in exposure to multiple contaminants that could cause adverse effects on the same human organs;

(b) where an unusual exposure scenario or a vulnerable population at the site requires a more stringent target level;

(c) where levels necessary to protect an aquatic organism or other environmental species or system are appropriate.

The Agency will prepare additional guidance in the near future to provide a more precise description of these and other circumstances that would warrant a lowering of the closure target levels.

If reduction of concentrations of constituents to background levels is used as a goal to be achieved during closure and post-closure care, these levels may not be appropriate for conservative metal constituents. If immobilization of metals is successful in the treatment zone, then background levels will not be achievable. An alternative approach may be to use the suggested maximum concentrations of metals that may be added safely to soils that are given in Tables 6.46 and 6.47 in Hazardous Waste Land Treatment (U.S. EPA 1983). The concentrations, based on literature and experience, were developed using microbial and plant toxicity limits, animal health considerations, and soil chemical properties that reflect the ability the soil to immobilize metals. Other pathways of exposure such as ingestion, however, were not considered.

Within 60 days after completion of closure, the owner or operator must submit to the Regional Administrator a certification that the HWLT unit has been closed in accordance with the approved closure plan. This certification must be signed by the owner or operator and by either an independent registered professional engineer or by an independent qualified soil scientist (Sections 265.115 and 265.280(e)). Within 60 days after certification of closure, the owner or operator must also submit to the local zoning authority or to the authority with jurisdiction over local land use, and to the Regional Administrator, a record of the type, location, and quantity of hazardous wastes disposed of at the unit (Section 265.119 (a)). The owner or operator

must record, in accordance with state law, a notation on the deed to the facility property, or on some other instrument that is normally examined during title search, that will notify any potential purchaser of the property that the land has been used to manage hazardous waste and that its use is restricted under Subpart G regulations (Section 265.119 (b)).

A post-closure permit will be required for all units that closed after January 26, 1983, except where a unit satisfies the requirements of Section 264.280 (e), i.e., no hazardous constituents have migrated beyond the treatment zone during the active life of the unit, and there are no hazardous constituents in the treatment zone above background levels at the time of closure. Certification of completion of post-closure care must be submitted to the Regional Administrator within 60 days of the completion of the established post-closure care period, according to the requirements given in Section 265.120.

1.4 GENERAL INFORMATION ON HAZARDOUS WASTE LAND TREATMENT

Land treatment is characterized in 40 CFR Section 265.272 (a) as follows: "Hazardous waste must not be placed in or on a land treatment facility unless the waste can be made less hazardous or non-hazardous by degradation, transformation, or immobilization processes occurring in or on the soil." Degradation of organic hazardous waste, hazardous waste constituents, and hazardous constituents as defined in 40 CFR Part 261 (i.e., Appendix VIII hazardous constituents), describes the loss of parent compounds through chemical and biological reactions within the soil/waste matrix. The rate of degradation may be established by measuring the loss of parent compound with time. Degradation and detoxification represent primary mechanisms for assimilation of organic waste constituents in a soil system. Transformation refers to the formation of intermediates during the process of degradation. Immobilization refers to the extent of retardation of the downward transport, or leaching potential, and upward transport, or volatilization potential, of waste constituents. Immobilization is the primary mechanism for treatment of hazardous metals in soil systems. Immobilization of organic waste constituents allows for time for degradation processes to occur. The mobility potential for waste constituents to transport from the waste to water, air, and soil phases is affected by the relative affinity of the constituents for each phase. The evaluation of soil treatment requires integration of the results of degradation, transformation, and immobilization processes for waste constituents of concern.

At a HWLT unit, waste is generally applied to the surface and/or incorporated into the soil. At some HWLT units, the waste is injected below the surface using subsurface injection techniques. The zone of incorporation (ZOI) represents the area and depth over which waste is applied; generally the ZOI is 15-20 cm (6-8 in.) in depth. The treatment zone includes the ZOI and the unsaturated soil below the ZOI where treatment is achieved. (In Section 264.271 (c), the maximum depth of the treatment zone is defined as 1.5 m (5 ft.)). Loading rate (amount of waste added per volume of land), and the frequency of waste application vary for each HWLT unit, and are generally functions of the waste degradation rate, waste production rate, and climate.

Unlike other land disposal options , including landfills, surface impoundments, and waste piles, where wastes are contained or stored indefinitely or for future disposal, HWLT units are designed to accomplish simultaneous treatment and ultimate disposal. The objective of HWLT achieves safe assimilation of wastes by the treatment soil through the processes of degradation, transformation, and immobilization. Additional information concerning the objectives, functions, and processes operating within an HWLT unit are provided in Hazardous Waste Land Treatment (U.S. EPA 1983) and in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a).

Chapter 2

FACTORS IN ADDRESSING CLOSURE AND POST-CLOSURE

2.1 INTRODUCTION

To achieve the objectives of closure and post-closure, the owner or operator must provide information concerning the type and amount of hazardous wastes applied to the HWLT unit during the active life of the facility, migration potential of the hazardous wastes and hazardous waste constituents, environmental site conditions, and waste residue characterization in the unsaturated zone.

2.2 HISTORY OF WASTE APPLICATION

The owner or operator of a HWLT unit should provide, as required in Section 265.280 (b) (1), information concerning past waste management practices. Table 2.1 lists suggested important waste management data and records. These records include available history of waste application (i.e., application rates, timing, and location) and available history of hazardous waste quality.

2.3 MOBILITY AND MIGRATION POTENTIAL

An assessment of mobility and migration potential of the hazardous waste and hazardous waste constituents at the unit into environmental pathways of exposure is necessary to address the objectives of closure, i.e., control of migration of constituents (Section 265.280(b)(2)). Assessment of mobility and migration potential is also necessary in selecting an appropriate closure method.

The extent of treatment and migration of constituents from wastes that have been applied to the HWLT unit may be assessed during a site reconnaissance investigation as part of closure activities. Determination of the potential for future migration of constituents requires information concerning the extent of immobilization and rate of degradation of constituents as affected by site/soil conditions.

Migration potential for organic and inorganic constituents may be evaluated and predicted using reconnaissance data supplemented as required with a combination of treatability studies, predictions based on known characteristics of the soil and waste constituents, and modeling using the approach presented in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a). Refer to the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a) for

TABLE 2.1 USEFUL WASTE MANAGEMENT DATA AND RECORDS

Category	Item	Specific Information
History of Waste Application	Years in service and annual quantity of waste land treated	Records of measured or estimated annual waste quantity treated over the life of the unit.
	Placement of wastes on land treatment plots	Records of quantity, date, and location of each waste application for each land-treated waste over the life of the HWLT unit, including management practices used
History of Waste Quality	Waste Analyses	Analyses of each land-treated hazardous waste applied during the operating life of the unit. (Non-hazardous waste analyses are also necessary if these wastes were land treated in the same plots as hazardous wastes.)

detailed information for determining migration potential. Prediction of the migration potential of organo-metallic complexes present in waste residues at closure is a difficult aspect of closure to evaluate at the present time. This difficulty is directly related to changes in physical, chemical, and biological properties that occur as a result of the complexation of organic constituents with metal species. The resulting organo-metallic complex may not have properties that are identified with either the organic fraction or the metal fraction. It is important to know the structure of the organo-metallic complex in order to predict and/or evaluate the degradation and mobility potential. Changes in either the organic or metal fraction may result in drastic changes in toxicity, persistence, and/or mobility.

2.4 ENVIRONMENTAL SITE CONDITIONS

Sections 265.280 (b) (3), (4), and (5) require the evaluation of environmental site conditions of the HWLT unit as they relate to the control of migration and transport of hazardous waste constituents to groundwater and surface water and to the control of the release of airborne particulate contaminants. Specifically, the regulations require that the following factors must be evaluated:

(1) site location, topography, and surrounding land use;

(2) climate, including amount, frequency, and pH of precipitation;

(3) geological and soil profiles;

(4) surface and subsurface hydrology of the site;

(5) soil characteristics, including cation exchange capacity, total organic carbon, and pH.

Additional soil properties that are important in waste treatment and mobility at HWLT units and should be assessed include soil texture, soil mineralogy, bulk density, particle density, available water capacity, porosity, saturated hydraulic conductivity, aeration status, nutrients, electrical conductivity, and buffering capacity. Data concerning any other soil and site conditions that may be required as input to the mathematical model for land treatment systems should also be collected if predictive modelling is used to evaluate migration potential and/or to choose an appropriate closure method.

Guidance concerning the use of site data for prediction of transport of hazardous waste constituents from the HWLT unit may be found in Chapter 3 of Hazardous Waste Land Treatment, (U.S. EPA 1983), in Contaminated Surface Soil In-Place Treatment Techniques (Sims et al. 1986), in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a).

2.5 WASTE RESIDUE CHARACTERIZATION IN THE UNSATURATED ZONE

The purpose of waste residue characterization in the unsaturated zone at the HWLT unit (Section 265.280 (b) (6) and (7)) is to detect and predict

migration of hazardous wastes and hazardous waste constituents in order to determine the effectiveness of land treatment during the active life of the facility and to choose and implement appropriate closure methods. Information from waste residue characterization may also be used in the mathematical model for land treatment to assess potential migration of residual hazardous wastes and hazardous waste constituents (Section 265.280 (b) (2)).

Since wastes at the HWLT unit do not exist separately from the environmental matrix, measurement of waste characteristics must be assessed as part of the soil matrix, and in the soil pore liquid, groundwater, and surface runoff. Thus analysis techniques will usually include collection of samples from the HWLT unit, extraction/digestion procedures to separate constituents from the environmental matrix, and chemical analyses of the constituents. The types of waste residue analyses recommended have been categorized into three groups, as shown in Table 2.2.

The analysis of specific characteristics or constituents to be measured in the waste residue/soil matrix should provide information concerning the potential treatability of a hazardous waste in a soil system (e.g., pH, nutrients, electrical conductivity), and should include analyses that are used to optimize the performance of other analytical procedures (e.g., oil and grease content affects the extraction and analysis of samples for specific organic constituents). These analyses have been designated Type I analyses (Table 2.2).

Type II and Type III analyses (Table 2.2) are concerned with analysis for specific hazardous waste constituents (i.e., the waste constituents for which the waste was listed) and hazardous constituents (i.e., additional Appendix VIII constituents other than those for which the waste was listed as hazardous) in the waste residue/soil matrix. Since EPA believes "it is necessary to include all hazardous constituents ... to ensure that all contamination is adequately addressed at closure" (51 FR 16425), it is recommended that hazardous constituents be analyzed as well as hazardous waste constituents (see page 5 of this manual). If approved by the permit writer, EPA may accept analyses for a subset of Appendix VIII compounds that are "reasonably expected to be in, or derived from, the wastes to be land treated" (Section 270.20 (b) (4)), when the wastes handled at a facility are from an identified process. A list of Appendix VIII constituents commonly found in petroleum wastes is included in Appendix A. Similar lists may be developed for other industrial waste processes but should be approved by the permit writer and/or EPA.

Type II analyses are designed to detect and monitor levels of organic constituents on a routine basis using sample extraction preparation techniques and gas chromatography (GC) and/or high performance liquid chromatography (HPLC) for detection of organic constituents. These analyses are used for known constituents such as those for which a waste was listed as hazardous or those listed in an approved subset of Appendix VIII constituents for a specific waste type. The use of Type II analyses allows for the processing of larger numbers of samples at lower costs than Type III analyses.

TABLE 2.2

SUGGESTED ANALYTICAL INFORMATION
(U.S. EPA 1987)

Type of Analysis	Purpose	Constituents	Media to be Sampled				
			Soil				
			Zone of Incorporation	Treatment Zone Below Zone of Incorporation	Below Treatment Zone	Soil-Pore Liquid*	Groundwater*
Type I	1. To provide information concerning the land treatability of a waste	Oil and grease	X	X	X		X
		Total organic carbon	X	X	X		X
		Extractable hydrocarbons**	X	X	X	X	X
	2. To optimize other analytical procedures	Total dissolved solids or electrical conductivity (EC)	X	X	X	X	X
		pH	X	X	X	X	X
		Nutrients (nitrogen, phosphorus, potassium)	X				

TABLE 2.2 CONTINUED

Type of Analysis	Purpose	Constituents	Media to be Sampled				
			Soil				
			Zone of Incorporation	Treatment Zone Below Zone of Incorporation	Below Treatment Zone	Soil-Pore Liquid*	Ground-water*
Type II	To detect, monitor, and quantify selected constituents	Metals***	X	X	X	X	X
		Constituents that exceed the maximum concentration listed in Table 1 of 40 CFR 261.24 that cause a waste to exhibit EP toxicity (Required)	X	X	X	X	X
		Constituents that caused the wastes to be listed as a hazardous waste (Required)	X	X	X	X	X
		Appendix VIII organic constituents (40 CFR 270.20) that are reasonably expected to be in, or derived from waste placed in or on the treatment zone of a land treatment unit (Recommended)	X	X	X	X	X

TABLE 2.2 CONTINUED

Type of Analysis	Purpose	Constituents	Media to be Sampled				
			Soil				
			Zone of Incorporation	Treatment Zone Below Zone of Incorporation	Below Treatment Zone	Soil-Pore Liquid	Ground-water
Type III	To identify and quantify Appendix VIII organic constituents	Appendix VIII organic constituents and intermediate degradation products	X	X	X	X	X

* If selected sites have previously installed samplers.
** If used as an indicator of amount of wastes applied.
*** Total concentrations and not EP toxicity data; if food chain crops are grown, analysis of arsenic, cadmium, lead and mercury required; analysis of all Appendix VIII metals recommended.

Type II analyses also include the detection of metals in the waste residue/soil matrix by the use of inductively coupled plasma (ICP) or atomic absorption (AA).

Type III analyses are designed to identify and quantify organic constituents using sample clean-up and extraction techniques and gas chromatography/mass spectrometry (GC/MS) for identification and quantification. These analyses are usually performed when the identity and levels of hazardous constituents are not known. They are also used periodically in conjunction with Type II analyses to confirm the accuracy of Type II techniques.

All procedures used to measure constituents should be those approved by EPA or should be recognized standard methods. Methods that may be used for analysis of constituents are described in Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846 (U.S. EPA 1987), in the Guidance for the Analysis of Refinery Wastes (U.S. EPA 1985a), in Standard Methods for the Examination of Water and Wastewater (APHA 1985), in Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater (U.S. EPA 1979), in Characterization of Hazardous Waste Sites, A Methods Manual. Volume 3: Available Laboratory Analytical Methods (Plumb 1984), and in Methods of Soil Analysis, Parts 1 and 2, Second Edition (Klute 1986, Page 1982). Additional information concerning specifically the analysis of waste constituents at HWLT units may be found in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a).

Unsaturated zone monitoring, including sampling of soil core and soil pore liquid, is used to accomplish waste residue characterization in the soil system.

Soil core sampling is used to determine the type, concentration, and depth of migration of hazardous waste constituents in the soil as compared to background concentrations, as required in Section 265.280 (b)(7). Guidance concerning soil core sampling, including procedures and equipment, depth of sampling, areal distribution of sampling, analysis of soil core sampling, and interpretation of soil core sample data is given in the Guidance Manual on Unsaturated Zone Monitoring for Hazardous Waste Land Treatment Units (U.S. EPA 1986b), the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a), in Preparation of Soil Sampling Protocol: Techniques and Strategies (Mason 1983), and in Soil Sampling Quality Assurance User's Guide (Barth and Mason 1984).

Soil-pore liquid monitoring is intended to detect rapid pulses of constituents that occur immediately after significant additions of liquids to the HWLT unit. Therefore, the timing of soil-pore liquid sampling is essential to the usefulness of this technique (i.e., scheduled sampling cannot be planned on a preset date, but must be coordinated with precipitation, irrigation, etc.). The use of several types of soil-pore liquid samplers is recommended to enhance the likelihood of obtaining samples. Discussions of soil-pore liquid sampling are presented in the Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986a) and in Permit Guidance Manual on Unsaturated Zone Monitoring for Hazardous Waste Land Treatment Units (U.S. EPA 1986b).

Information collected as required for waste residue characterization should be representative of the waste residue/soil system. Sampling designs should provide information of maximum reliability. Statistical plans, including knowledge of the expected variability and confidence limits of both the analytical methods used and the sampling designs employed, should be incorporated in the closure plan. It is recommended that the owner or operator secure the services of a statistician familiar with the design of sampling and monitoring studies to prepare the sampling plan.

Chapter 3

METHODS FOR ADDRESSING CLOSURE BASED ON MOBILITY AND MIGRATION POTENTIAL

3.1 SUGGESTED CLOSURE METHODS

In order to address the goal of closure and post-closure of controlling the migration of hazardous waste and hazardous waste constituents from the HWLT unit to the environment (Section 265.280 (a)), Section 265.280 (c) requires that at least three methods be considered and discussed by the owner/operator in the closure plan. These approaches include:

(1) removal of contaminated soil from the land treatment unit;

(2) placement of a final cover over the unit, such as a vegetative cover or a clay or synthetic cap; and

(3) continued groundwater monitoring.

An additional method is also suggested for use:

(4) continued treatment of the waste residue in the soil system, with the use of treatment amendments and enhancements as required.

A combination of these methods may also be considered. Examples of such combinations include:

(a) partial removal of contaminated soil (e.g., the ZOI soil) and placement of a vegetative cover or a cap of clay or synthetic material;

(b) partial removal of contaminated soil, continuation of treatment, possibly using amendments to enhance treatment, and placement of a vegetative cover or cap; or

(c) no soil removal, continuation of treatment, possibly using amendments, and placement of a vegetative cover.

Additional options not presented here may also be used if the control of migration of constituents of concern can be achieved.

3.2 FACTORS TO BE CONSIDERED IN THE SELECTION OF A CLOSURE METHOD

The selection of one of the four options presented in this guidance for use in closure requires the evaluation of several potential sources of

information, including information collected from the reconnaissance investigation of the unit, environmental site and soil conditions, laboratory studies, and/or mathematical modelling to predict potential pathways and extent of migration. The factors presented for consideration in the following sections are not meant to be exhaustive but are indicative of the types of information that may be used in the choice of an appropriate closure method.

3.2.1 Selection of Removal of Contaminated Soil as a Closure Method

The use of soil removal should be considered if information concerning mobility and migration potential indicates that:

(1) unsatisfactory migration of constituents of concern from the unit has occurred;

(2) environmental site and soil conditions (e.g., high precipitation, low evapotranspiration, soils of high permeability and/or low sorptive capacity, high runoff potential, soil considerations) indicate a high potential for migration;

(3) the characteristics of residual constituents (e.g., high volatility, high degree of water solubility, high concentrations) indicate a high potential for migration;

(4) the degree of hazard presented by the residual constituents suggests that the contamination should be removed (direct exposure opportunity/potential effect on post-closure); and/or

(5) the results of the use of the mathematical model for land treatment indicate a high potential for migration.

Partial removal of contaminated soil should be considered if constituents with higher potential for migration and/or higher toxicity are concentrated in the upper soil layers, e.g., the ZOI. Additional closure activities may be necessary to stabilize the new soil surface and control migration of remaining constituents.

3.2.2 Selection of a Cover Over the Unit as a Closure Method

Two types of covers, which act to control migration in different ways, are suggested for use. In general, factors to be considered in the use of either type of cover, i.e., vegetative cover or capping, include:

(1) unsatisfactory migration of constituents from the unit has not occurred;

(2) environmental site and soil conditions (e.g., moderate to low precipitation and high evapotranspiration, soils with moderate to high sorptive capacity) indicate a moderate to low potential for migration from the unit; and

(3) residual waste constituents are at low to medium concentrations, exhibit moderate potential for transport in percolating water or in air, and/or are of low residual toxicity;

Specific factors that should also be considered in the selection of vegetation as a cover include:

(1) a lower potential for migration to groundwater exists such that the primary purpose of the cover would be to minimize direct contact and inhalation of residual constituents and to control erosion and run-off; and

(2) there may be potential for continued in-place treatment of waste residuals in the soil system during the post-closure period.

The use of capping with clay or synthetic materials should be evaluated using the following factors:

(1) migration of constituents in percolating water would be minimized or eliminated if infiltration were controlled;

(2) migration of constituents to the atmosphere would be minimized or eliminated if a cap were used that reduced vapor transport or particulate windborne erosion;

(3) the type of constituents present would not present a greater threat to human health and the environment under the anaerobic conditions that would likely develop below a clay or synthetic cap (e.g., if cessation of further treatment, greater mobility, and/or higher toxicity might result, and/or methane migration might occur); and

(4) waste(s) and waste(s) constituents would be isolated from a direct contact pathway.

3.2.3 Selection of the Use of Continued Groundwater Monitoring as a Closure Method

The use of continued monitoring of the HWLT unit as it was operated during the active life of the facility without additional closure activities should be considered according to the following factors:

(1) no migration of constituents of concern has occurred from the HWLT unit;

(2) there is little or no potential for future migration of constituents from the unit, as indicated by site and soil conditions, residual waste characteristics, laboratory studies, and/or predictive mathematical modelling; and

(3) there is no danger from direct contact with waste residuals.

3.2.4 Selection of Continued In-Place Treatment as a Closure Method

Factors that should be considered in the selection of the use of in-place treatment as a closure method include:

(1) waste residues are capable of further treatment in the soil system; and

(2) potential migration of waste residuals during the closure period is low.

3.3 REMOVAL OF CONTAMINATED SOIL AS A CLOSURE METHOD

Complete or partial removal of contaminated soils at the HWLT unit may be used to eliminate or reduce the source of contamination at the unit.

3.3.1 Description of Excavation and Disposal

Excavation is a common technique used in earth-moving projects and is widely used to move solid and thickened sludge materials. Excavation is achieved by mechanical means. Typical excavation equipment includes draglines, backhoes, earthmovers, and bulldozers. The hazardous waste contaminated soil excavated from an HWLT unit must be disposed of in a RCRA-approved hazardous waste facility. Arrangements for disposal must be made as part of the closure plan.

Technical guidance concerning excavation technology and costs associated with excavation, transportation and disposal are presented in the Handbook for Remedial Action at Waste Disposal Sites (U.S. EPA 1982a) and in Liners for Sanitary Landfills and Chemical and Hazardous Waste Disposal Sites (U.S. EPA 1978).

3.3.2 Advantages and Disadvantages of Excavation and Disposal to Completely Remove Contaminated Soil

The use of excavation and disposal is not recommended as the sole closure method for HWLT units unless there is a severe potential for migration of hazardous waste constituents from the unit or potential for direct exposure to toxic levels of hazardous waste(s) or constituents following closure. Waste residues left in the soil at HWLT units may be subject to further treatment in the soil, however, to render them less or non-hazardous. The availability of space in another RCRA-approved facility for the large quantities of soils associated with an HWLT unit may be limited and difficult to locate.

However, an advantage to the use of excavation and disposal as a closure method is that if the unit has been excavated to such a depth so as to completely remove the source of contamination, it should therefore present no threat to human health and the environment, and activities associated with post-closure care may be limited under Section 265.118 (f). However, a post-closure permit will be required unless the requirements of Section 264.280 (e) are met.

Partial removal of contaminated soils may reduce the major source of constituents with a higher potential for migration from the unit and/or a higher degree of hazard from direct contact. Additional closure methods may then be implemented to further control expected pathways of migration of remaining constituents.

3.4 ESTABLISHMENT OF A FINAL COVER AS A CLOSURE METHOD

Two types of covers should be considered: vegetative covers and clay or synthetic caps. Covers are used to minimize or eliminate infiltration into the soil and to stabilize the soil surface.

3.4.1 The Use of Vegetation as a Final Cover

The use of vegetation as the final surface cover is highly recommended at the HWLT unit to prevent water and wind borne erosion and transport of soil/waste materials, to provide infiltration control into the soil, and to allow continued treatment of hazardous constituents.

The vegetative cover should be established at such time that the cover will not impede the treatment of hazardous constituents. Since certain operating practices to accomplish and enhance treatment, such as tilling, cannot be performed without damaging or destroying the vegetative cover, the owner or operator should postpone establishing the vegetative cover until satisfactory treatment has occurred following the last application of waste. Results from unsaturated zone monitoring, treatment zone soil analyses, and run-off monitoring should be used to determine the degree of treatment achieved. Once the cover is established, operating practices that are inconsistent (e.g., tilling) with establishment and maintenance of the vegetative cover should be discontinued (U.S. EPA 1983). Long-term vegetative stabilization generally involves the planting of grasses, legumes, and shrubs.

Technical guidance concerning the establishment of a vegetative cover at HWLT units may be found in Hazardous Waste Land Treatment (U.S. EPA 1983), Handbook for Remedial Action at Waste Disposal Sites (U.S. EPA 1982a), and in Evaluating Cover Systems for Solid and Hazardous Waste (Lutton 1982).

3.4.1.1 Description of Vegetative Cover--

In order to establish vegetation at an HWLT unit, the following factors should be addressed in the closure plan (U.S. EPA 1983):

(1) Selection of species adapted for the site

(2) Seedbed preparation

(3) Seeding/planting

(4) Management practices for cover maintenance

3.4.1.1.1 Selection of Species--

The selection of suitable plant species for vegetating a closed HWLT unit depends on cover soil characteristics and site and plant characteristics, as shown in Table 3.1.

Perennial grasses such as fescue that have dense root systems that anchor soil and enhance infiltration provide a quick and lasting ground cover. Legumes (e.g., lespedeza, vetch, clover) fix nitrogen from the atmosphere in their roots, enhancing soil fertility and assisting the growth of grasses. Shrubs also can provide a dense surface cover. A mixture of plants will allow more efficient use of soil moisture and nutrients at various depths. Trees are generally planted in the later stages of revegetation, after legumes and grasses have established a stable ground cover. They help to provide long-term protective cover and build up a stable, fertile layer of decaying leaves/branches.

TABLE 3.1. FACTORS FOR SELECTION OF PLANT SPECIES (U.S. EPA 1982a, U.S. EPA 1983)

Site/Soil Characteristics	Plant Characteristics
Texture	Ease of establishment
Organic content	Sensitivity to residual waste constituents
Nutrient and pH levels	Tolerance to soil characteristics
Soil water content	Ability to control erosion
Climate	Productivity
Site hydrology (slope steepness and drainage characteristics)	Ability to withstand competition with undesirable plants
	Availability of seed at reasonable cost
	Ease of maintenance
	Resistance to diseases and insect damage
	Water tolerance
	Suitability for future land use
	Desirable species (not noxious or poisonous)

Information concerning the suitability of specific plant species for revegetation of HWLT units are presented in Table 3.5 in the Handbook for Remedial Action at Waste Disposal Sites (U.S. EPA 1982a), in Table 8.11 in Hazardous Waste Land Treatment (U.S. EPA 1983), and in Tables 11, 12, and 13 in Evaluating Cover Systems for Solid and Hazardous Waste (Lutton 1982).

Other sources of information are highway cut revegetation standards available from most state highway departments and recommendations from the Soil Conservation Service, state agricultural extension services, and/or agronomy departments at universities. In some cases, plant species may be used in climatic zones other than those recommended if special conditions unique to the HWLT unit would permit their use, e.g., when the use of irrigation provides additional moisture.

The use of food-chain crops for vegetating an HWLT requires special considerations, as given in Section 265.276. These regulations must be followed if food-chain crops are to be grown. Before growing food chain crops, the owner or operator must demonstrate, based on field testing, that any arsenic, lead, mercury, or any constituent that caused the waste to be listed as a hazardous waste will not be transferred to the food portion of the crop by plant uptake or direct contact, and will not be ingested by food chain animals. The owner or operator also must demonstrate that these constituents will not occur in greater concentrations in crops grown on the HWLT unit than in the same crops grown on untreated soils under similar conditions in the same region. If the wastes applied to the HWLT unit contain cadmium, special requirements concerning annual and cumulative applications of cadmium must be met, as given in Sections 265.276 (c).

Selection of suitable plant species for HWLT units that have had oily wastes applied may be difficult because at this time there are little data available on the revegetation of these sites with perennial plants. Streebin et al.(1984) prepared a literature review on the effects of oily wastes on the growth of plants. Problems identified for plant growth include phytotoxic waste constituents and impaired water, air, and nutrient relations. The authors recommended that research be conducted to identify and develop plants that are tolerant to oily wastes.

Because of possible impacts that wastes at an HWLT unit may have on the growth of vegetation, the use of a demonstration study of selected plant species or potential species is recommended. The study may be conducted in field plots at the site, or a greenhouse simulation study may be performed. Possible protocols for conducting these types of studies are presented in Field and Laboratory Evaluation of Petroleum Land Treatment System Closure (Overcash et al. 1985).

3.4.1.1.2 Seedbed Preparation--

Seedbed preparation is necessary to create a favorable environment for the rapid germination and growth of the planted species. The characteristics of an adequate seedbed include:

(1) appropriate pH level

(2) adequate nutrients

(3) freedom from live vegetation

(4) firm soil below seeding depth

(5) adequate amounts of mulch, plant residues, or chemical stabilizers on the soil surface

Applications of lime are used to neutralize acidic soils, while acidifying agents may be added to soils with too high pH levels. Fertilizers are added to provide essential plant nutrients. The amount of lime or acidifying agents and fertilizers required should be determined from site-specific soil tests.

Plowing is the most common method of preparing a seedbed to destroy existing vegetation and to create a favorable soil density. Mulches or plant residues are added to the soil to conserve soil moisture, dissipate raindrop energy, moderate soil temperatures, prevent crusting, increase infiltration, and control wind and water erosion. Mulches may also be used as a seedbed to protect seeds from injury from volatile and dissolved constituents during germination and early growth.

3.4.1.1.3 Seeding/Planting Program--

The development of a successful vegetative stand also depends on an effective seeding/planting program. Elements of a seeding program include:

(1) seeding/planting method

(2) seeding/planting rate

(3) seeding depth

(4) timing of seeding/planting

Seeding should be performed as soon as possible after seedbed preparation. The most common methods of seeding are broadcasting and drilling. Drilling is usually preferred, since seed/soil contact is important for successful stand establishment. The effectiveness of broadcasting may be enhanced by following seeding with harrowing or discing to increase seed/soil contact. Hydroseeders may also be used, which spray seed, fertilizer, mulch, and lime at one time. However, phytotoxicity of residual waste constituents may cause difficulty in germination and may require the use of mulches to protect seeds and developing seedlings from toxic constituents in the waste/soil matrix.

Hand planting may be required for trees and shrubs. Until trees have recovered from the initial shock that planting causes their root systems, they should not be exposed to oil contaminated soils (Streebin et al. 1984). In order to buffer roots from treated soil and to give trees time to establish themselves before the roots come into contact with contaminated soil, a large

hole about twice the size normally used to plant the tree should be used and filled in with uncontaminated soil.

The use of a proper seeding rate is also critical to the establishment of a vegetative stand. The quantity of seed applied depends on the plant species, the method of seeding, and waste/soil characteristics.

Optimum seeding depth depends on seed size, quantity of stored energy in the seeds, and texture of the surface soil (U.S. EPA 1983). If seeds are planted too deep, there may not be enough stored energy to allow developing seedlings to reach the soil surface. Too shallow seeding may result in desiccation of the seed. Seed may be planted deeper in lighter-textured soils than in heavier textured soils.

The optimum time for seeding is dependent on the local climate and the requirements of the individual plant species. Seeding/planting should be performed under favorable temperatures and soil moisture conditions. For perennial species, early fall seeding is usually recommended (U.S. EPA 1982a). Annuals are usually best seeded in spring and early summer, although they can be planted whenever soil is damp and warm. In mild climates (e.g., southeastern United States) the planting of both summer and winter grasses will extend the period of time of active growth at the site.

3.4.1.1.4. Management Program--

A management program of periodic maintenance should be established to ensure the long-term establishment and functioning of the vegetative cover. Periodic reliming and fertilization may be necessary to maintain optimum growth. Soils with poor buffering capacity may require frequent liming to maintain suitable pH levels. Periodic fertilization using appropriate fertilizer formulations, time of application, and method of application will also aid in revegetation efforts. Mowing and the judicious use of selective herbicides will help control undesirable weed and brush species. Grass sodding and remulching or planting new shrubs and trees is recommended for sparsely covered areas.

3.4.1.2 Advantages and Disadvantages of Vegetative Cover--

An advantage of closing the HWLT unit by establishing a vegetative cover is that the wastes are left in place and continued treatment of any remaining constituents can occur in the soil system. Vegetation will also help to reduce the potential for transport of hazardous constituents from the HWLT unit by control of wind and water erosion and by evapotranspiration, which by decreasing the amount of percolating water, may decrease the transport of hazardous constituents to the groundwater.

However, since the wastes are left in place, there exists potential for migration into the environment. There also exists potential for uptake by plants and biomagnification through the food-chain, and for future exposure to humans by direct contact if treatment to levels below toxic levels is not successful.

3.4.2 The Use of Capping as a Final Cover

Capping is the process by which an HWLT unit is covered to prevent surface water infiltration, control erosion, and isolate and contain the contaminated soil/waste mixtures at the unit. A variety of cover materials and capping techniques are available for use. The choice of an appropriate capping material and method of application is dependent on site-specific factors, including:

(1) local availability and costs of cover materials

(2) desired function of cover material (e.g., control of water infiltration, water and wind erosion control, crack resistance, settlement control and waste containment, side slope stability, support of vegetation, suitability for future site use)

(3) type and properties of waste/soil mixture being covered

(4) local climate and hydrogeology

(5) projected future use of the site

The use of capping at waste disposal sites is discussed in the Handbook for Remedial Action at Waste Disposal Sites (U.S. EPA 1982a), in Design and Construction of Covers for Solid Waste Landfills (Lutton et al. 1979), in Evaluating Cover Systems for Solid and Hazardous Waste (Lutton 1982), and in the RCRA Guidance Document: Landfill Design, Liner Systems and Final Cover (Draft) (U.S. EPA 1982b).

3.4.2.1 Description of Capping as a Closure Method--

Soil materials used for capping an HWLT unit must be relatively impermeable and erosion-resistant. Fine-grained soils such as clays and silty clays have low permeability but tend to be easily eroded by wind if left exposed, especially in arid climates. Coarse, heavy grained soil materials provide more protection from wind erosion, but are highly permeable.

Fine- and large-grained soil materials may be mixed to enhance strength of the soil cover, minimize wind erosion, and reduce infiltration. Mixing may be accomplished in situ using a blade or harrow to turn and mix the soil materials.

Laboratory and field-testing of physical and chemical properties of potential soil materials may be required to choose an appropriate material for use as a capping material. Technical guidance concerning interpretation of test results is given in Lutton et al. (1979).

Other techniques to form a protective cover over an HWLT unit include adding amendments to the native soil or using synthetic capping materials. If the unit is to be closed as a hazardous waste landfill, the unit should be closed in conformance with guidance provided in the RCRA guidance document (U.S. EPA 1982b).

Grading techniques are used in conjunction with capping to modify topography and runoff characteristics to control infiltration and erosion. A discussion of grading and associated costs are presented in the Handbook for Remedial Action at Waste Disposal Sites (U.S. EPA 1982a). The cap should also be vegetated to stabilize the surface of the HWLT unit.

3.4.2.2 Advantages and Disadvantages of Capping--

In general, the use of capping as a closure method for a HWLT unit is not recommended. HWLT relies on aerobic soil conditions to degrade applied hazardous waste constituents. Conditions under a cap are likely to become anaerobic, thus inhibiting or preventing additional treatment that could occur during the post-closure period. Anaerobic conditions may also favor the production of toxic compounds (e.g., methylation of mercury and arsenic) and the mobilization of toxic metals. The use of capping, however, may be more appropriate if the unit was operated as a landfill de facto.

In addition, the cap must be graded to reshape the surface to manage surface water infiltration and runoff and re-vegetated to provide a stabilized surface. Caps also require long-term maintenance and care. Unsaturated zone monitoring must also be conducted in such a manner as to ensure the integrity of the cap.

3.5 CONTINUED GROUNDWATER MONITORING AS A CLOSURE METHOD

Groundwater monitoring provides a means for addressing the objective of control of migration (265.280 (a)) by the owner/operator of a HWLT unit. Monitoring data can be used to make changes in the closure and/or post-closure plants). Based on results of groundwater monitoring it may also be necessary to undertake corrective action measurements at the HWLT site. If constituents are present in groundwater monitoring samples at trigger levels then corrective action measures may be necessary during the closure or post-closure period. Therefore, continued groundwater monitoring provides a means for determining appropriate responses, if any are required, to ensure that the objective of control of migration is achieved during closure and post-closure.

3.6 IN-PLACE TREATMENT AS A CLOSURE METHOD

In-place treatment technologies may be used as a closure method to contain the source of contamination (e.g., by immobilization) or to remove it through treatment (e.g., by degradation). Technical guidance concerning the selection and implementation of in-place treatment techniques is given in Review of In-Place Treatment Techniques for Contaminated Surface Soils (U.S. EPA 1984).

3.6.1 Description of In-Place Treatment

In-place treatment techniques may be divided into the following categories, defined in terms of their primary action on the contaminants in the soil: immobilization, degradation, and reduction of volatilization (U.S. EPA 1984). These techniques include using the naturally occurring capacities of the soil to accomplish treatment, supplemented as required with amendments

or management and operational practices to accomplish the desired degree of treatment.

Immobilization techniques are designed to retain waste constituents within the contaminated soil, reducing the rate of migration of the constituents to groundwater, surface water, or atmosphere exposure pathways. Soil systems have inherent capacities for immobilization of both organic and inorganic constituents, but if additional capacity is required, amendments may be added to alter soil properties that improve the immobilization capacity.

Immobilization includes sorption, ion exchange, and precipitation. Sorption processes are important in the immobilization of both organic and inorganic constituents. Organic matter, both naturally occurring in soils and added in the form of manures and other agricultural by-products, may be used for sorption of waste constituents. Activated carbon may also be used as a sorbent, especially for organics.

Ion exchange is a process in which minerals and resins in contact with a solution release ions in preference for ions of another type in the solution. In soils, clays and organic matter participate in ion exchange reactions. Synthetic resins and zeolites as well as clay minerals and organic matter may be added to enhance the natural capacity of the soil to remove constituents by ion exchange. Soil pH is also important in the exchange capacity of a soil. Ion exchange is important in immobilizing hazardous metals, but also may be applicable to organic constituents.

Precipitation is a process in wh ch inorganic constituents that are initially soluble react and form compounds of very low solubility, and are thereby retained in the soil instead of being removed by percolating water. Precipitating agents can be added directly to the soil or generated in-place by a chemical or biochemical reaction.

Degradation techniques are used to convert waste constituents into innocuous or less toxic compound or compounds and are generally applicable primarily to organic constituents.

Biological degradation utilizes the action of micro-organisms. Naturally occurring micro-organisms found in nearly every soil system can often degrade organic constituents. Promotion of biological degradation can be accomplished by altering selected soil properties, such as moisture and pH, aerating the soil, or adding nutrients. Addition of selectively adapted or genetically engineered organisms may enhance degradation of some wastes.

Chemical degradation processes include oxidation reactions, reduction reactions, and polymerization reactions. Naturally occurring reactions can be enhanced by adding additional reagents to the soil system or by modifying selected soil properties such as soil moisture.

Photodegradation of organic constituents can occur by the action of incident solar radiation. The organics must be present or brought to the surface of the soil (e.g., by volatilization or mechanical mixing of the soil) for this process to be effective. Enhanced photodegradation may be

accomplished through the addition of various proton donors to the contaminated soils.

Volatilization of constituents from the HWLT unit may require control to reduce air emissions or to retain constituents within the soil system to allow for other in-place treatment processes to occur. Reduction of volatilization may be accomplished by reduction of soil vapor volume, use of physical/chemical barriers, and soil cooling.

Design and implementation of an in-place treatment process requires information on characteristics of the soil/waste system. In general, these types of processes are most applicable to soils contaminated to shallow depths and are only applicable to waste constituents treatable by the specific process. Treatability studies of a specific process using the waste constituents of concern and the soils present at the HWLT unit are recommended to determine the natural capacity of the soil system as well as the capacity of the amended or modified soil system to achieve a satisfactory level of treatment.

After closure using in-place treatment technology has been completed, the soil surface must be stabilized to prevent water and windborne erosion and runoff.

3.6.2 Advantages and Disadvantages of In-Place Treatment Techniques

In-place treatment techniques allow for continued treatment of waste residues in the soil system, thus reducing the potential for migration of these constituents to the environment. Many of the techniques are easily implemented and relatively inexpensive.

However, because the wastes are left in place, there does exist potential for migration of, as well as direct contact with, the waste residues. Long-term stability of many types if immobilized constituents has not yet been well-defined, especially under changing environmental conditions. Degradation processes may result in intermediate products equally or more hazardous than the parent compounds.

Chapter 4

MANAGEMENT DURING CLOSURE

4.1 INTRODUCTION

In addition to the requirements given in Subpart G, Part 265, which includes the continuation of groundwater monitoring to ensure that closure performance standards are met (Section 265.112 (b) (5)), the owner or operator of an HWLT unit must continue unsaturated zone monitoring, maintain run-on control and runoff management, and control wind dispersal of particulate matter during the closure period (Section 265.280 (d) (1), (2), (3), and (4)).

4.2 UNSATURATED ZONE MONITORING

The owner or operator must continue unsaturated zone monitoring, including soil pore liquid and soil core sampling during the closure period. The purpose of the monitoring is to detect vertical migration of hazardous waste and hazardous waste constituents under the active portion of the HWLT unit and to provide information on the background concentration of the hazardous waste and hazardous waste constituents in similar but untreated soils.

Results of monitoring may be used to assess the effectiveness of the selected method of closure as it is being implemented. Monitoring below the treatment zone will indicate whether constituents are migrating out of the treatment zone. Monitoring through depth within the treatment zone allows the owner or operator to determine the extent of degradation and immobilization of constituents.

Soil-pore liquid monitoring detects rapidly moving waste constituents, so movement of these constituents should occur soon after the last application of waste, depending on the input of moisture to the site (i.e., precipitation or irrigation at the site). Therefore, soil pore liquid monitoring may be terminated 90 days after the last application of waste to the treatment zone (Section 265.280(d)(1)). However, it is recommended that soil pore liquid monitoring continue until three consecutive samples are free of statistically significant increases of hazardous constituents over background (U.S. EPA 1983).

The soil pore and soil core liquid monitoring system used during the active life of the facility should be continued to be used during the closure period. Technical guidance concerning unsaturated zone monitoring may be found in the Guidance Manual on Unsaturated Zone Monitoring for Hazardous

Waste Land Treatment Units (U.S. EPA 1986b), and in The Permit Guidance Manual on Hazardous Waste Land Treatment Demonstrations (U.S. EPA 1986b).

4.3 RUN-ON AND RUN-OFF CONTROL

Water control is required during the closure period of an HWLT unit (Part 265.280(d)(2) and (3)), since water may be the primary means of transport of hazardous constituents to off-site land surfaces, surface waters, or groundwater. Hazardous constituents may either be transported as dissolved substances or suspended in the water. Water management is used to limit the amount of water contacting treated areas and to minimize precipitation run-off from treated areas. Any precipitation run-off is collected for storage and disposal.

A HWLT unit undergoing closure under Part 265 should already have in place an operating run-on control system as required under Part 265.272(b) and a precipitation run-off management system as required under Part 265.272(c). Guidance concerning the design and operation of precipitation run-on and run-off control management systems may be found in Chapter 8 of Hazardous Waste Land Treatment (U.S. EPA 1983), and in J. Skinner Memorandum, November 4, 1984, Management of Precipitation Runoff from Land Treatment Units.

4.4 CONTROL OF DISPERSAL OF PARTICULATES

Many hazardous constituents can be tightly bound to soil materials. Soil particles from an HWLT unit can be entrained into the air and transported off-site by wind,resulting in human exposure by direct inhalation. Indirect exposure can result if these particulates are deposited in agricultural fields, pastures, or waterways and thereby enter the food-chain (U.S. EPA 1985).

Control of wind erosion may be accomplished by reducing windspeed on the soil surface or by forming a new, less erodible soil surface. Technical guidance design and management of wind erosion control systems may be found in Dust Control at Hazardous Waste Sites (Rosbury 1985) and in Hazardous Waste Land Treatment (U.S. EPA 1983).

Chapter 5

MANAGEMENT DURING POST-CLOSURE

5.1 POST-CLOSURE REQUIREMENTS

The owner or operator of the HWLT unit must develop a post-closure plan that will identify activities that will be carried on after closure to comply with the requirements of Section 265.117, including groundwater monitoring requirements (Subpart F of Part 265) and specific requirements for HWLT units in Subpart M, Section 265.280 (f). During the post-closure care period, which may extend for 30 years after the date of completion of closure (unless shortened according to Section 265.117 (a) (2) (i)), the following activities must be performed:

(1) ground water monitoring must be continued in accordance with Subpart F of Part 265;

(2) soil core monitoring must be continued;

(2) access to the unit must be restricted as appropriate for its post-closure use (Section 265.117 (c)). Guidance concerning site security is presented in Hazardous Waste Land Treatment (U.S.EPA 1983);

(3) growth of food chain crops must comply with the guidance given in Section 265.276; and

(4) wind dispersal of hazardous wastes must be controlled.

Post-closure use of property on or in which hazardous wastes remain after closure must never be allowed to disturb the integrity of the final cover or any other components of the containment system or the function of the monitoring systems (Section 265.117 (c)).

5.2 DURATION OF POST-CLOSURE CARE

The Regional Administrator may reduce the post-closure care period specified in the post-closure plan if there is evidence that the secure nature of the facility indicates that post-closure care requirements may be reduced or eliminated (Section 265.117 (a) (2) (i)). Such evidence might include leachate or groundwater monitoring results. The Regional Administrator may also extend the post-closure care period if necessary to prevent threats to human health and the environment (Section 265.118 (a) (2) (i)).

Additional reasons for reducing the post-closure care period might include site conditions where threats to human health and the environment from the applied waste are very low, i.e., there is low potential for migration from the site. Such a site could include the following characteristics: deep groundwater (e.g., greater than 200 feet), low precipitation and high evaporation (e.g., desert environment), no surface water body nearby, soil conditions that are suitable for easy establishment of volunteer vegetation, little wind action to prevent dispersal of airborne contaminants, and no observation of soil movement (e.g., soil creep) during the closure period.

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APPENDIX A

TABLE A.1. CONSTITUENTS OF PETROLEUM REFINING WASTES

1. Metals

Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Lead
Mercury
Nickel
Selenium
Vanadium

2. Volatiles

Benzene
Carbon disulfide
Chlorobenzene
Chloroform
1,2-Dichloroethane
1,4-Dioxane
Ethyl benzene
Ethylene dibromide
Methyl ethyl ketone
Styrene
Toluene
Xylene

3. Semivolatile Base/Neutral Extractable Compounds

Anthracene
Benzo(a)anthracene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Bis(2-ethylhexyl) phthalate
Butyl benzyl phthalate
Chrysene
Dibenz(a,h)acridine
Dibenz(a,h)anthracene
Dichlorobenzenes
Diethyl phthalate
7,12-Dimethylbenz(a)anthracene
Dimethyl phthalate
Di(n)butyl phthalate
Di(n)octyl phthalate
Fluoranthene
Indene
Methyl chrysene
1-Methyl naphthalene
Naphthalene
Phenanthrene
Pyrene
Pyridine
Quinoline

4. Semivolatile Acid-Extractable Compounds

Benzenethiol
Cresols
2,4-Dimethylphenol
2,4-Dinitrophenol
4-Nitrophenol
Phenol